DOCUMENT RESUME

ED 250 155 SE 045 128

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TITLE The Effect of Three Types of Brain-Based Instruction on the Mathematics Achievement and Attitudes of Second Grade Students.
PUB DATE 4 Sep 84
NOTE 16p.
PUB TYPE Reports - Research/Technical (143)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Educational Research; Elementary Education; *Elementary School Mathematics; Geometric Concepts; Grade 2; *Manipulative Materials; Mathematics Achievement; *Mathematics Instruction; Measurement; Student Attitudes; *Teaching Methods; *Textbooks
IDENTIFIERS *Brain Research; *Mathematics Education Research

ABSTRACT

This study explored the effects of a left-hemispheric, right-hemispheric, or integrated teaching approach on students' achievement and attitudes. One hundred eighteen second-grade pupils were randomly assigned to four groups to receive two weeks of instruction on geometry and measurement with: (1) a formalized, structured-textbook approach; (2) a variety of hands-on, manipulative activities without use of a textbook; (3) a textbook and manipulative approach; or (4) no instruction on the mathematics unit. Half of the pupils took the pretests and half took the posttests. The greatest gain in achievement and attitudes occurred with the manipulative approach (right hemispheric), while the textbook approach (left hemispheric) resulted in the least gains. (MNS)

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ED250155

The Effect of Three Types of Brain-Based Instruction on the Mathematics Achievement and Attitudes of Second Grade Students

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The Effect of Three Types of Brain-Based Instruction on the Mathematics Achievement and Attitudes of Second-Grade Students

Introduction

For years, both children and adults have displayed different styles of thinking, and during the instructional process, they employ different forms of learning. This differentiation in learning and thinking styles among individuals has been found to be related to each individual's particular hemispheric preference (Galin, 1974).

The unique, specialized functions of the left and right hemispheres have been adequately supported by numerous research studies (Bogen & Bogen, 1969; Bogen, 1975; Galin, 1976; Krashen, 1975, 1976; Ornstein, 1972; Sperry, 1973). Typically, the left hemisphere processes information in a linear, logical, sequential, and rational manner. Memory is retained in words by the left hemisphere, and through this hemisphere individuals communicate verbally and analytically. The inference is that the academic subjects of reading, writing, and arithmetic are primarily left hemispheric functions.

On the other hand, the right hemisphere processes information in a spatial, holistic, relational, and appositional style. A person who activates this hemisphere prefers to use visual/spatial or manipulative materials in learning and

communicates best through the academic subjects of art, music, physical education, geometry, and dance (Shannon & Rice, 1983). With the current emphasis on "back to basics" the mass educational system in the United States has placed a heavy emphasis on the verbal, linear, and conforming functions of the left hemisphere while failing to acknowledge the importance and value of the right hemispheric processes. According to Wolfe and Reising (1978) "Schools are 'left brain institutions' and are becoming more so with the current demands for accountability and the demands for concrete measurements of student achievement in reading, writing, and mathematics" (p. 30).

Several recent studies, however, stress that learning seems to depend on the integration of both the left and right hemispheres. Levy (1983), for example, strongly disputes the idea that students learn with only one side of the brain. Research by Levy suggests that learning cannot be accomplished by either side of the brain alone but is an integrative activity. Levy states that "children need to learn how to engage their whole brains in feeling, thinking, understanding and achieving satisfaction" (p. 71).

Hart (1983), a major reviewer of brain research, argues that schools limit the learning potential of students by the way they organize and present information. Hart suggests that schools need to reorganize to become "brain-compatible."

According to Raina (1979), education should provide opportunities for a balance between the right hemisphere's spatial-synthetical modality and the left hemisphere's verbal-

analytical modality. Raina suggests that educators introduce new concepts in an analytical manner with verbal emphasis, followed by nonverbal "hands-on" exploration of materials to encourage the development of neurological symmetry. Sinatra (1983) maintains that through activities children form schema and learn the cognitive skills of comparing, contrasting, categorizing, sequencing, and evaluating. Sinatra's research emphasizes the point that right-hemisphere stimulation during the early years of child development may be the foundation for later learning during the higher-grade levels. Several other studies indicate that a combined hands-on, manipulative/textbook approach using both brain-processing modes improves the achievement of students in the elementary classroom (Hart, 1981; Hider & Rice, 1982; Levy, 1983; Raina, 1979; Wolfe & Reising, 1978).

Purposes

The purpose of this study was to examine the effect of three types of brain-based instruction (left, right, and both) on student achievement in second-grade mathematics and on attitudes toward playing mathematics games and doing mathematics lessons. The following questions were addressed:

(1) Will a left-hemispheric-teaching approach improve students' mathematical achievement compared to a right-hemispheric, manipulative-instructional approach?

(2) Will an integrated-instructional approach, involving both left- and right brain-hemispheres improve students' mathematical achievement?

(3) Will students' attitude toward mathematics vary depending upon the three different types of brain-based-instructional approaches?

Procedures

One hundred and eighteen subjects were randomly selected from several second-grade classrooms in urban elementary schools in southern Alabama. The design of the study consisted of the separate sample, pre-test/post-test control group design as outlined by Campbell and Stanley (1963). All subjects were randomly assigned one of four treatment groups. Group one received mathematics instruction in a formalized, structured-textbook approach using teaching techniques which were logical and analytical. Group two's mathematics instruction consisted of a variety of hands-on, manipulative activities without the use of the textbook. Group three received mathematics instruction which included both a textbook and manipulative approach. Group four served as the control group and received no instruction on the mathematics unit.

On the first day of a two-week instructional period, half of the subjects (fifty-nine) were given a pre-test dealing with their attitude toward mathematics and an achievement test to measure their knowledge of geometry and measurement. The Open

Math Student Survey developed by Knaupp (1974) was used to measure student attitude toward mathematics. A criterion-referenced test consisting of thirty-three items was developed to measure students' knowledge of geometry and measurement. During the last class period, the remaining students (fifty-nine), who had not taken the pre-test, received the post-test. All instructional content during the treatment period was identical and was taught in thirty minute periods by teachers who were trained to teach in a particular way depending upon the treatment group to which they were assigned.

Results

Achievement means for the treatment groups were compared using analysis of covariance with pre-test scores as the covariate. The overall F for the significance of adjusted means was 26.92, which was significant at the $p < .01$ level with 3 and 54 degrees of freedom. The adjusted means for Group Two (the manipulative group) were significantly higher ($p < .001$) than the means for the other groups (see Tables One and Two). The adjusted means for Group One (textbook), Group Two (manipulative) and Group Three (textbook/manipulative) were 23.63, 28.49, and 24.99 respectively.

Insert Tables One and Two About Here

Scheffe tests for two-group comparisons indicated that all three treatments produced greater achievement than did the control group. The greatest achievement occurred in Group Two (manipulative) using the right hemispheric instructional approach. Group One (textbook) using the left hemispheric instructional approach achieved the least gain (see Table two.)

A scale of one to five (five is high) was used on the attitude scale to identify the degree of student attitude toward mathematics on each item. There was a significant effect ($p < .01$) of the adjusted treatment means with an overall F of 4.48 (see Table Three). As can be seen in Table Four, the attitude post-test means were higher for Group Two (manipulative) and Group Three (textbook/manipulative) which indicates greater improvement in student attitude toward mathematics within these groups.

Insert Tables Three and Four About Here

The Scheffe tests for two-group comparison indicated that there was no change in attitude for students in Group One

(textbook). The greatest increase in attitude occurred in Group Two (manipulative) at $p < .03$. Group Three (textbook/manipulative) also indicated some improvement at $p < .06$. The least change in attitude occurred in Group One (textbook) and the greatest positive gain in Group Two (manipulative).

Discussion

The results of this study were consistent with previous research which emphasized the importance of a more balanced approach to instruction in the elementary school (Fischer & Rhead, 1974 and Brooks, 1980). The data collected demonstrate that the students in the manipulative group (Group 2) had the greatest gains in achievement and in their attitude toward mathematics. This finding is similar to Sinatra's (1983) research which emphasizes the importance of right hemisphere stimulation during the early years of child development. the data also suggest that students in the lower grades might profit more by using the manipulative-instructional approach in mathematics instead of placing so much emphasis on the textbook approach.

Results of this study also reveal that the textbook/manipulative group (Group Three) had gains in achievement and attitude although not as great as in Group Two. The textbook-only group (Group One) had the lowest gains in

achievement and positive attitudinal increases.

Teachers should give serious consideration to using more manipulatives in the teaching of mathematical concepts. What is needed is a divergence from the traditional curriculum to a novel curriculum using diversity in teaching methods which encourages and accepts both modes of thinking and learning.

The implications of this study suggest that educators should become receptive to the belief that two different modes of processing information exist and that the use of both modes can be used to improve achievement and attitudes in mathematics. For children to develop to their full potential, the development of the whole brain is necessary during instruction.

Further inquiry needs to be made into brain-based instruction using larger sample sizes and different age groups. Hopefully, this study will stimulate further comparison of this nature.

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Table One

Analysis of Covariance:
Comparison of Mathematics Achievement
for Three Types of Brain-Based Instruction

Mathematics Achievement Pre-Test = Covariate (X)

Mathematics Achievement Post-Test = Criterion (Y)

Sources	SS(X)	SS(Y)	(XY)	Adj. SS(Y)	DF	Adj. $\bar{X}$S(Y)
Between	108.33	544.77	36.47	545.69	3	181.89
Within	1088.41	902.41	764.90	364.86	54	6.75
Total	1196.74	1447.18	801.37			

Homogeneity of Regression	F = 7.90	P < .001
Treatment	F = 26.92	P < .001
Regression	F = 75.13	P < .001

Table Two

Means, Standard Deviations and Scheffe Tests:
Comparison of Mathematics Achievement
for Three Types of Brain-Based Instruction

Treatment Groups	Achievement Pre-Test	Achievement Post-Test	Mathematics Achievement Tests (Adjusted)
Group I (Textbook)			
$\bar{X}$	20.64	24.43	23.63
SD	5.90	2.61	
Group II (Manipulative)			
$\bar{X}$	17.88	27.33	28.49
SD	4.43	3.74	
Group III (Combined Textbook/Manipulative)			
$\bar{X}$	21.14	26.14	24.99
SD	2.67	3.58	
Group IV (Control)			
$\bar{X}$	18.62	19.56	20.18
SD	3.60	5.11	

Scheffe Test for Two-Group Comparisons (3 and 54 degrees of freedom)		
Textbook with Control	$F = 4.26$	$P < .001$
Manipulative with Control	$F = 26.23$	$P < .001$
Combined Textbook/Manipulative with Control	$F = 8.17$	$P < .001$

Table Three

Analysis of Covariance
Comparison of Attitude Toward Mathematics
with Three Types of Brain-Based Instruction

Mathematics Attitude Pre-Test = Covariate (X)

Mathematics Attitude Post-Test = Criterion (Y)

Sources	SS(X)	SS(Y)	(XY)	Adj. SS(Y)	DF	Adj. $\bar{X}$S(Y)
Between	.33	5.96	1.02	5.25	3	1.75
Within	24.31	24.07	8.50	21.10	54	.39
Total	24.64	30.03	9.52			

Homogeneity of Regression	F = 1.02	P < .39
Treatment	F = 4.48	P < .01
Regression	F = 7.18	P < .01

Table Four

Means, Standard Deviations and Scheffe Tests:
Comparison of Attitude Toward Mathematics
with Three Types of Brain-Based Instruction

Treatment Groups	Attitude Pre-Test	Attitude Post-Test	Mathematics Attitude Tests (Adjusted)
Group I (Textbook)			
$\bar{X}$	3.35	3.35	3.39
SD	.72	.61	
Group II (Manipulative)			
$\bar{X}$	3.46	3.93	3.93
SD	.50	.68	
Group III (Combined Textbook/Manipulative)			
$\bar{X}$	3.57	3.93	3.89
SD	.62	.46	
Group IV (Control)			
$\bar{X}$	3.44	3.25	3.25
SD	.70	.75	

Scheffe Test for Two-Group Comparisons (3 and 54 degrees of freedom)

Textbook with Control	$F = .12$	$P < .94$
Manipulative with Control	$F = 2.99$	$P < .03$
Combined Textbook/Manipulative with Control	$F = 2.52$	$P < .06$